Error Detection

Q1.

a. In a CRC error detection scheme, choose $P(x) = X^4 + X + 1$. Encode the bits 10010011011 using Shifted Polynomial method.

Converting data to polynomial format;
$10010011011 = X^{10} + X^7 + X^4 + X^3 + X + 1$

Establishing length of FCS;
$P(x) = X^4 + X + 1 = 10011$ -> So length of FSC will be 5 bits – 1 = 4 bits.

Applying shifting to data;
$X^4(X10 + X^7 + X^4 + X^3 + X + 1) = X^{14} + X^{11} + X^8 + X^7 + X^5 + X^4$

Calculate FCS;

$$
\begin{array}{l}
\qquad\qquad\qquad X^{10} + X^6 + X^4 + X^2 \\
\hline
X^4 + X + 1 \;\; / \;\; X^{14} + X^{11} + X^8 + X^7 + X^5 + X^4 \\
\qquad\qquad\qquad X^{14} + X^{11} + X^{10} \\
\hline
\qquad\qquad\qquad\qquad X^{10} + X^8 + X^7 + X^5 + X^4 \\
\qquad\qquad\qquad\qquad X^{10} + \qquad X^7 + X^6 \\
\hline
\qquad\qquad\qquad\qquad\qquad X^8 + X^6 + X^5 + X^4 \\
\qquad\qquad\qquad\qquad\qquad X^8 + \qquad X^5 + X^4 \\
\hline
\qquad\qquad\qquad\qquad\qquad\qquad X^6 \\
\qquad\qquad\qquad\qquad\qquad\qquad X^6 + X^3 + X^2 \\
\hline
\qquad\qquad\qquad\qquad\qquad\qquad\quad X^3 + X^2
\end{array}
$$

Note :
Highlight to students when to stop this process. It stops when the power of the leading X is SMALLER than the leading power of the pattern.

So;
$FSC = X^3 + X^2$

Converting to bits;
$FSC = X^3 + X^2 = 1100$

Append to data bits;
Bits sent = 100100110111100

b. Repeat the above problem using Base-2 method.

Using Base 2 method

In base 2 method, we use XOR between the data bits and the pattern bits.

XOR table

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

Data bits are;
10010011011

Establishing length of FCS;
P(x) = $X^4 + X + 1$ =10011 -> So length of FSC will be 5 bits – 1 = 4 bits.

Shifting to left and inserting 4 zeros in the end (similar to shifted polynomial)

10010011011<u>0000</u>

Calculate FCS;

```
100100110110000
10011
---------
       10110110000
       10011
       --------
          101110000
          10011
          -------
             1000000
             10011
             --------
                  1100
```

So;
FCS = 1100

Append to data bits;
Bits sent = 100100110111100

c. Suppose the channel introduces errors and the string 000110110111100 is received. Can the error be detected?

Bits received = 000110110111100
= $X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$ ***Note to students ; No shifting done on receive side !***

$$X^7 + X^6 + X^3 + X^2 + X$$

$$X^4 + X + 1 \quad / \quad X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$$
$$X^{11} + \quad X^8 + X^7$$

$$X^{10} + X^5 + X^4 + X^3 + X^2$$
$$X^{10} + X^7 + X^6$$

$$X^7 + X^6 + X^5 + X^4 + X^3 + X^2$$
$$X^7 + \quad X^4 + X^3$$

$$X^6 + X^5 + X^2$$
$$X^6 + X^3 + X^2$$

$$X^5 + X^3$$
$$X^5 + X^2 + X$$

$$X^3 + X^2 + X$$

ERRORS DETECTED…!!!!

Base-2 Method:

Received bits
000110110111100

Perform base 2 method again

```
000110110111100
10011
--------
100000110111100
10011
--------
    110110111100
    10011
    -------
     10000111100
     10011
     --------
         11111100
         10011
         ---------
          1100100
          10011
          --------
           101000
```

10011

1110

Since the remainder is not 0, there are errors detected.

d. If 000010110111100 is received will an error be detected?

Bits received = 000010110111100 = $X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$

Do error check;

$$X^6 + X^4 + X^2$$

$$X^4 + X + 1 \quad / \quad X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$$

$$X^{10} + X^7 + X^6$$

$$X^8 + X^6 + X^5 + X^4 + X^3 + X^2$$

$$X^8 + X^5 + X^4$$

$$X^6 + X^3 + X^2$$

$$X^6 + X^3 + X^2$$

NO ERRORS DETECTED (So CRC is not fool-proof)

Q2.

What is the difference between odd parity and even parity?

In parity error control, an extra bit is added to each row of data.

The value (1 or 0) of this extra bit is set according to whether odd or even parity is used.

In even parity, the bit is set so that the number of 1s in the row is even. EG

Data bits						Parity bit
Data Row 1	1	1	0	1	0	1
Data Row 2	0	1	1	1	1	0

Note that for even parity, the parity bit can be 1 or 0, as required.

In odd parity, the bit is set so that the number of 1s in the row is odd. EG

Data bits						Parity bit
Data Row 1	1	1	0	1	0	0
Data Row 2	0	1	1	1	1	1

Note that for odd parity, the parity bit can be 1 or 0, as required.

Two dimensional parity checking is also possible be adding parity bits to the columns as well.